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(71) Applicant: CADEA D.O.O. [HR/HR]; Trg Mihovila Pavlinovica 6, 21000 Split (HR).

(72) Inventor: MAGAZINOVIC, Gojko; Trg Mihovila Pavlinovica 6, 21000 Split (HR).

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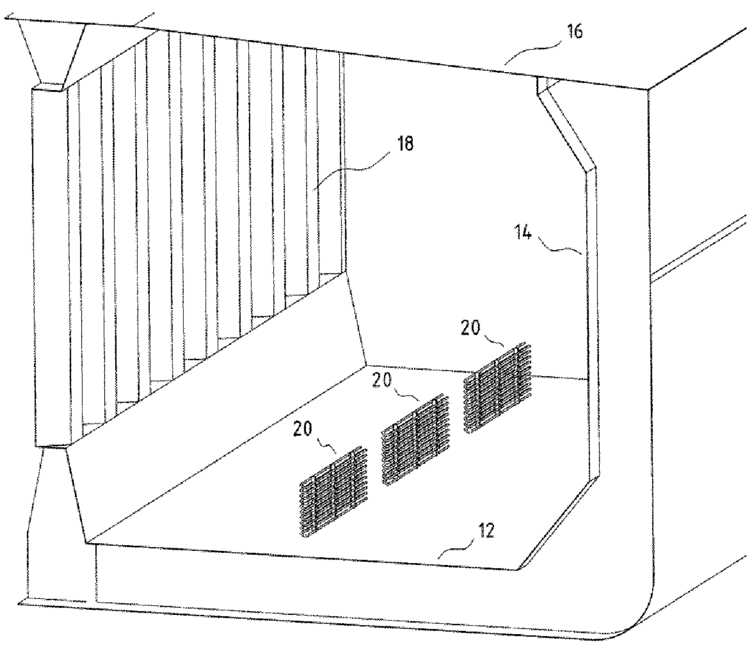

Fig. 6

(57) Abstract: In an embodiment of the invention, a heating coil bundle (20) for a tank (10) heating comprising one heating coil body and three supports (40) is disclosed. The bundle (20) is comprised of a plurality of straight tubes (32) and a plurality of U-shaped tubes (34) that are leak-proof serially joined at their open ends and extended in parallel and spaced-apart relationship to each other and arranged in a plurality of levels (24). The bundle (20) cross-section is characterized by a binary-matrix-like tube pattern (22) of M rows (24) and N columns (26). The disclosed heating coil bundle (20) generates a heated fluid (50) large-scale circulation (52) and superimposes said large-scale circulation (52) driven forced convection on a buoyancy driven natural convection, providing a more effective heat transfer mechanism.

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MULTI-LEVEL HEATING COIL BUNDLE

Field of the invention

The present invention relates to tanker cargo heating equipment.

Background of the invention

Tankers transport various types of high viscosity fluids that require significant effort during their off-loading. Therefore, the tankers are equipped with a means for cargo heating that, by increasing the fluid temperature, reduce their viscosity and enhance the fluid off-loading.

The equipment for tanker cargo heating is traditionally executed as steam-driven heating coils, evenly distributed all over the tank bottom, with heating tubes arranged along a single or two levels, that transfer the heat from steam to the fluid by a natural convection mechanism. The cumulative length of tanker heating coils is above few thousand meters, and hence the tanker cargo heating equipment is an important item in the tanker building cost. Application of the more effective heating coils enables the reduction of the required heating coils length and hence the reduction of the tanker overall building costs.

In a paper I. Pivac, G. Magazinovic, Numerical analysis of tank heating coil heating process, in C. Guedes Soares et al. (Eds.), Towards Green Marine Technology and Transport, CRC Press, London 2015, pages 603-608, the authors reported numerical simulation results that disclose an existence of a powerful heated fluid circular motion about an axis that is normal to a tank transverse cross-section, page 608 of the paper. The reported motion is a manifestation of the phenomenon already known in the art as the so-called large-scale circulation, see R. Krishnamurti and L. N. Howard, Large-scale flow generation in turbulent convection, Proc. Natl. Acad. Sci. USA, Vol. 78, No. 4, pp. 1981-1985, April 1981.

The heated fluid large-scale circulation is an essence of the present invention as it enables a more effective heat transfer mechanism by superimposing a large-scale circulation driven forced convection on buoyancy driven natural convection, see VDI Heat Atlas, Springer-Verlag, Berlin 2010, page 684.

When the patent documentation is concerned, the Japanese utility application JP3048878U (Shin Kurushima Dockyard, 1998) discloses a retractable heating unit with the heating tubes arranged in one level only. The task to be solved was a simplification of the tank cleaning process by enabling a revolvement of the heating unit and providing access to the solidified cargo remnants below the unit; Fig. 1 of a cited document. Also, the document teaches a conventional heating coil arrangement, wherein the heating coils cover a significant part of the bottom of the tank area; for example, Fig. 2 of a cited document shows that around 40% of the bottom of the tank area is covered by heating coils.

The present application provides an alternate approach to solve the problem. According to the present application embodiment, the heating coil bundle is characterized by a very small footprint; accessible for easy cleaning without the need for the bundle removal. In addition, the most of the bottom of the tank area remain free of any tank heating equipment. For example, less than 2.5% of the bottom of the tank area is covered by the heating coil bundles; Fig. 6 of the present application.

The Chinese patent CN101362509A (Wenchong Shipyard, 2009) discloses an installation method for a plurality of the bunker tanks. A two-level heating coil arrangement is disclosed. The task to be solved was a reduction of the hard work during the coil installation. Since the coils are arranged close to the vertical tank wall; Fig. 1 of a cited document; enclosed by the vessel’s structural elements; the possibility of the heat transfer improvement by the fluid circulation is limited.

The Japanese utility model application JPS5353786U (Hitachi Zosenkan, 1978) discloses a multi-level heating coil bundle comprising seven tube levels and five tubes per level; Fig. 3 of a cited document; wherein a bundle length is determined by a bottom of tank particulars. The task to be solved was a heating unit of high heating efficiency. However, the disclosed embodiment is enclosed by a vessel’s structural elements; (16) in Fig. 4 of a cited document; that greatly suppress the heated fluid free flow. As a consequence, the possible heat transfer improvement is limited. In addition, the disclosed embodiment comprises a heating fluid inlet (10) arranged in a downmost tube level and a heating fluid outlet (11) arranged in the uppermost tube level; Fig. 3. The probable outcome is a water hammer difficulty, caused by the flow of condensing steam.

The present application provides an alternate approach to solve the problem, wherein the heated fluid cross-flow enhances the heat transfer. Also, to suppress the water hammer difficulty, the heating fluid inlet and heating fluid outlet are arranged in the tube uppermost and downmost levels, respectively.

The Japanese patent application JPH0569893A (Shin Kurushima Dockyard, 1993) discloses a method of installation of a heating pipe into a cargo tank. The document discloses a single-level heating coil bundle that leads to the significant reduction in labor; Figs. 1 and 2 of a cited document.

The British patent application GB1054066A (J.H. Jefferson, 1967) discloses a displaceable two-level heating coil bundle for cargo holds intended for solid and liquid cargoes. A plurality of heating coils is arranged in two parallel rows; Fig. 2 of a cited document; wherein nearly all of a bottom of the tank area is covered by heating coils.

The Japanese patent JP2007238054A (Sumitomo Heavy Industries, 2007) discloses a single-level heating coil arrangement that solves two problems: a reduction of a ballast tank paint burnouts due to a welding works; and leaving a passage on the bottom of the tank for a work vehicle. The document discloses an asymmetric heating coil arrangement, wherein the heating coils are situated near the vessel's longitudinal bulkhead; Figs. 1 and 2 of a cited document. The document also discloses a heated cargo circulation, enhanced by using a convection plate (9). However, since the heating coils are party situated in the corner of a tank; where the heated fluid velocities are the least; the effects of the cargo circulation are limited. Also, the majority of the bottom of the tank area is covered by heating coils, wherein the covered area may be estimated to around 60% of the bottom of the tank area; Fig. 2 of a cited document.

The present application provides an alternate approach to solve the problems, wherein the passages on both sides of the heating coil bundles are provided. Furthermore, due to a small number of the bundle supports; for example, Fig. 6 of a present application discloses nine supports; the occurrences of the ballast tank paint burnouts are limited.

Summary of the invention

According to the present invention, there is provided a heating coil bundle for a tank heating comprising at least one heating body comprising a plurality of straight tubes and a plurality of U-shaped tubes, a plurality of fastening means, and at least one support to form a compact and rigid structure that is extended horizontally, close above a bottom of the tank.

The provided heating coil bundle is characterized by:

it generates a heated fluid large-scale circulation about an axis that is parallel to the straight tubes longitudinal axes,

it enables a nearly horizontal cross-flow of the heated fluid through a void space surrounding the straight tubes and U-shaped tubes, and

it provides a more effective heat transfer mechanism by superimposing the large-scale circulation driven forced convection on the buoyancy driven natural convection.

The heating body is built of straight tubes and U-shaped tubes that are leak-proof serially joined at their open ends, wherein joining sequence starts by joining the straight tube and the U-shaped tube, then proceeds by a series of consecutive joining, on the U-shaped tube open-end side, of tube pairs comprising the straight tube and the U-shaped tube, respectively, and finally completes by joining yet another straight tube. The outcome is a single heating body with one fluid inlet and one fluid outlet, arranged in a plurality of parallel and vertically spaced apart heating coil tube levels, fixed to the support by using the plurality of fastening means.

The heating coil bundle cross-section, perpendicular to a straight tube axis, has a binary-matrix-like tube pattern of M rows and N columns, wherein a row count M is a total number of the heating coil tube levels the heating coil bundle is arranged and a column count N is the greatest number of the straight tubes arranged in any of M heating coil tube levels. The heating coil tube level is characterized by comprising at least one straight tube of a unique distance between the straight tube axis and the bottom of the tank.

The tube pattern of Figure 2 is characterized by six rows and three columns, while the tube pattern of a bundle depicted in Figure 3 is characterized by 20 rows and one column only. The number of heating tubes arranged at the tube level may vary. If any tube level comprises less than N tubes, the remaining elements of the pattern row are left empty, see, for example, Figure 2. The tube pattern depicts the bundle tube arrangement disregarding tube pitches, i.e., the vertical pitch between the levels may vary, as well as the horizontal pitch between the tubes of the same level.

The heating fluid inlet is always situated in the uppermost level of the heating body, Figure 3, to suppress the possible water-hammer difficulties. Similarly, the heating fluid outlet is always situated at the downmost level of the heating body. Considering the heating fluid temperature is the highest at the fluid inlet, and lowest at the fluid outlet, the higher tube levels are thermally more effective than the lower ones. The binary-matrix-like tube pattern enables layouts with more straight tubes arranged in the thermally more effective higher levels, and less straight tubes arranged in the thermally less effective lower levels, as depicted in Figure 2.

The tank heating process starts by heating fluid filling the void spaces of the heating coil bundle tubes. Heating fluid rises the temperature of the heating tubes that transfer the heat to the surrounding heated fluid by a natural convection heat transfer mechanism. The heated fluid, close to the heating tubes, due to buoyancy effect, starts to move upwards, generating a dominantly vertical flow of the higher temperature fluid, and a plurality of small fluid whirls caused by friction between higher-temperature and lower-temperature fluid particles. As time goes on, when the plume of the heated fluid reaches the tank top, gradually starts a process of whirl concentration, wherein the majority of small whirls ends in one large whirl, also known as the large-scale circulation. The result is a dominantly circular motion of the heated fluid, wherein the fluid streamlines take a form of concentric circles, Figure 7. The heated fluid large-scale circulation is generated by a convective energy inflow from the asymmetrically positioned heating coil bundle, Figure 1, and further enhanced by convective energy outflows through the tank walls, wherein sufficient heating duration is required to develop said large-scale circulation fully.

The heating coil bundle enables a nearly horizontal cross-flow of the large-scale circulation through voids surrounding the straight tubes and U-shaped tubes, Figure 1 and 7. It is an important feature due to the two reasons. Firstly, the horizontal cross-flow makes the shortest cross-flow path through the bundle, hence incurring the least pressure loss for the fluid flow. Secondly, the horizontal cross-flow resembles the large-scale circulation path in the bundle’s region, generating a least detrimental effect on the heated fluid flow structure.

The present application fulfills a plurality of the long-felt needs known in the art. Besides an improvement in the heat transfer, the present application is characterized by:

the present application reduces a covered bottom of the tank area, enabling a more efficient tank cleaning;

the present application leaves the passages for the work vehicles; and

the present application reduces difficulties related to the ballast tank paint burnouts; caused by the welding works.

Brief description of the drawings

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a transverse section of a tank in which a heating coil bundle and a heated fluid large-scale circulation outlines have been drawn in dashed lines;

Figure 2 shows a general heating coil bundle binary-matrix-like tube pattern;

Figure 3 shows a preferred embodiment of the heating coil bundle;

Figure 4 shows a heating fluid transfer tube;

Figure 5 shows a heating fluid transfer tube with an expansion bend as a thermal expansion compensation device;

Figure 6 shows a preferred embodiment of a tank heating system, wherein the heating fluid supply and discharge lines are omitted for the sake of clarity; and

Figure 7 shows numerical simulation results indicating a heated fluid large-scale circulation.

Detailed description of the preferred embodiment

A tank (10) filled with a liquid cargo (50), Figure 1, is equipped with a heating coil bundle (20); extended in parallel and spaced-apart relationship to a tanker longitudinal symmetry plane (2) and a tank inner side wall (18), slightly closer to the tank inner side wall (18) than a tank outer side wall (14); that is joined to a tank bottom (12) by utilizing a plurality of supports (40). The tank bottom (12) is a planar surface, mostly free of any structure or equipment that may obstruct the fluid flow. The tank (10) is capped by a deck (16).

The heating coil bundle (20), Figure 3, is pre-manufactured in a workshop and erected into the tank (10), wherein the supports (40) are joined to the tank bottom (12), and the heating fluid inlet (31) and heating fluid outlet (39) are leak-proof joined to the corresponding heating fluid supply and discharge lines.

If the heat generated by one heating coil bundle (20) is not sufficient for the tank (10) heating requirements, a plurality of the heating coil bundles (20) needs to be installed, Figure 6. For the sake of clarity, in Figure 6, the heating fluid supply and heating fluid discharge lines are not shown.

Heating tubes (32) and (34), Figure 3, are made of carbon steel; stainless steel; or some copper-based alloys; depending on a kind of cargo the tanker transports. The tubes are joined to each other by welding if the tubes are steel-based, or brazing, if the tubes are made of copper alloys. The heating tubes (32) are fixed to the support (40), by using fastening means (42), usually U-shaped bolts and nuts. The heating coil bundle (20) is driven by steam, a heating fluid, generated in a boiler situated in a tanker engine room. The steam is distributed by steam header along the tanker deck, wherein a steam manifolds branch the steam intended to each heating body. From the deck (16) level steam downcomers, extended along tanker transverse bulkheads, guide the steam to the tank bottom (12) level, wherein horizontal transfer tubes are utilized to supply the steam to each heating body inlet (31).

The heating coil heats the surrounding liquid by a heat transfer from the steam to cargo liquid. Due to heat energy outflow, the steam gradually condenses. The tube length of the heating body has to be sufficient to condense the steam completely. A condensate, after leaving the heating body outlet (39) is guided through the horizontal transfer tubes up to the transverse bulkhead, wherein a condensate lift; a riser; and a steam trap; are used to connect the heating body outlet (39) to the condensate manifold at the deck (16) level. The condensate manifolds guide the condensate further to a condensate header that returns the condensate to the engine room and the boiler.

The heating coil bundle (20) cross-section has a binary-matrix-like tube pattern (22) of 20 rows, and one column as each tube level (24) comprises one straight tube (32) only. Although the tube pattern (22) is characterized by one pattern column, the heating coil bundle (20) is executed by the heating tubes (32) arranged in two physical columns, each column occupying one of the opposite sides of the supports (40), Figure 3.

The supports (40) might be executed in different ways, from the simple single-part standard profiles, as depicted in Figure 3, to more complex built multi-part structures capable of securely holding the heating coil bundle (20). The built multi-part supports are appropriate for the heating coil bundles characterized by more complex binary-matrix-like tube patterns (22), Figure 2.

Although said heating tubes (32) may be arranged in as low as three levels (24), the heating coil bundles (20) arranged in the higher number of the tube levels (24) are thermally more effective than the ones arranged in the lower number of the tube levels (24). Consequently, the heating coil bundle (20) of Figure 3 is characterized by high thermal efficiency and low manufacturing costs, due to a simple and compact design.

A distance between the inner side wall (18) and heating coil bundle (20) closest straight tube (32) centerline ranges from 0.3 to 0.7; preferably from 0.4 to 0.45; times the tank (10) width.

The bundle (20) is situated in a middle part of the bottom of the tank (12), Figure 1, wherein the large-scale circulation (52) velocity profile is the most powerful concerning the intended cross-flow through voids surrounding the straight tubes (32) and the U-shaped tubes (34). However, a slight deviation from the ideal midpoint is a preferable feature of the provided embodiment as an exact midpoint position generates a less stable large-scale circulation, prone to changes in the circulation (52) direction.

The vertical pitch, i.e., a vertical distance between two consecutive tube levels (24) of the tube pattern (22), should be sufficiently large to enable an easy cross-flow of the heated fluid (50) through the voids surrounding said straight tubes (32) and said U-shaped tubes (34); wherein a tube pattern (22) vertical pitch to said straight tube (32) outer diameter ratio is at least 1.25; preferably at least 3.

Another embodiment of the present invention further comprises at least one heating fluid transfer tube (36), Figure 4; characterized in that: said heating fluid transfer tube (36) is a single body with one fluid inlet and one fluid outlet; said heating fluid transfer tube (36) is extended in parallel and spaced-apart relationship to said straight tubes (32); and said heating fluid transfer tube (36) is fixed to said support (40) by using said plurality of fastening means (42).

Yet another embodiment of the present invention further comprises at least one tube thermal expansion compensation device (38); characterized in that said heating fluid transfer tube (36) and said tube thermal expansion compensation device (38) are leak-proof serially joined at their open ends, providing a single body with one fluid inlet and one fluid outlet. Figure 5 depicts such a heating fluid transfer tube (36), wherein said tube thermal expansion compensation device (38) is executed in the form of an expansion bend.

When the tank (10) heating requirements are too high to be fulfilled by said heating coil bundle (20), a plurality of said heating coil bundles (20) should be arranged within the tank (10), exclusively extended in an exactly one row, in a longitudinally spaced apart relationship from each other, Figure 6., to minimize the bundle’s (20) detrimental effect on the flow structure of the heated fluid.

Each said heating coil bundle (20) heating body possesses its heating fluid supply line and its heating fluid discharge line, wherein said heating fluid supply line and said heating fluid discharge line hydraulically connect said heating body inlet (31) and said heating body outlet (39) with the corresponding headers on the deck (16) level.

As a plurality of the heating coil bundles (20) is aligned in a row, along the tank (10) length, a plurality of parallel supply and discharge lines is needed to span a long distance between the vertical downcomers and risers, extended along the tank transverse bulkhead, and the corresponding heating fluid inlets (31) and outlets (39). In such configurations, the heating coil bundles (20) situated closer to the bulkhead, may assist the heating fluid transfer to, and from, the bundles (20) situated farther in a row. Furthermore, said heating fluid transfer tubes (36); parts of the respective heating coil bundles (20); are conveniently utilized as sections of the supply lines and sections of the discharge lines.

The large-scale circulation (52) impact on the heating coil bundle (20) thermal effectiveness is numerically verified by a transient simulation performed by using a buoyantPimpleFoam solver of an OpenFOAM® 3.0 toolbox, a finite volume method software; see, for example, F. Moukalled et al., The Finite Volume Method in Computational Fluid Dynamics: An Advanced Introduction with OpenFOAM® and Matlab®, Springer-Verlag, Cham 2016, pages 103-135 and 561-690.

For verification purpose, a two-dimensional domain (10) of Figure 1, filled with a 585 mm^2/s viscosity oil, discretized in around 150000 cells, and heated by a 7 bar steam-driven heating coil bundle (20) built of 50A-size steel tubes, Figure 3, is subjected to three-hour heating.

The following table summarizes obtained results; wherein a pre-LSC column refers to a pre-circulation fluid flow phase, during the initial 2700 seconds of heating; while an LSC column refers to a developed large-scale circulation fluid flow phase, during the remaining 8100 seconds of heating.

Physical quantity	pre-LSC	LSC
Peak cross-flow velocity, m/s	0.067	0.184
Average cross-flow velocity, m/s	0.021	0.076
Average Richardson number, -	95.2	7.3

According to page 298 of a book Y. I. Cho, G. A. Greene, Advances in Heat Transfer, Volume 43, Academic Press, San Diego 2011, Richardson number is a measure of the relative strength of the buoyancy induced current with respect to the imposed flow. The reported fall of an average Richardson number from 95.2 to 7.3 indicates that said large-scale circulation (52) enhances, for an order of magnitude, the influence of said bundle (20) forced convection heat transfer with respect to said bundle (20) natural convection heat transfer.

Typical simulated large-scale circulation streamlines are provided in Figure 7.

Claims

1. A heating coil bundle (20) for a tank (10) heating comprising:

at least one heating body comprising a plurality of straight tubes (32) and a plurality of U-shaped tubes (34);

a plurality of fastening means (42); and

at least one support (40) to form a compact and rigid structure; characterized by:

said straight tubes (32) and said U-shaped tubes (34) are leak-proof serially joined at their open ends, providing a single heating body with one fluid inlet and one fluid outlet; fixed to said support (40) by using said plurality of fastening means (42); joined to a bottom of tank (12) by utilizing said support (40);

said straight tubes (32) and said U-shaped tubes (34) are arranged in at least three parallel and vertically spaced apart heating coil tube levels (24), wherein a heating fluid inlet (31) is arranged in said heating body uppermost tube level (24), and a heating fluid outlet (39) is arranged in said heating body downmost tube level (24); and

a plurality of said heating coil bundles (20) is exclusively extended in an exactly one row, in a longitudinally spaced apart relationship from each other.

2. The heating coil bundle (20) for the tank (10) heating of claim 1, further characterized in that said straight tubes (32) and said U-shaped tubes (34) joining sequence starts by joining said straight tube (32) and said U-shaped tube (34), then proceeds by a series of consecutive joining, on said U-shaped tube (34) open-end side, of tube pairs comprising said straight tube (32) and said U-shaped tube (34), respectively, and finally completes by joining yet another said straight tube (32).

3. The heating coil bundle (20) for the tank (10) heating of claim 2, wherein said heating coil bundle (20) is extended in a parallel and spaced apart relationship from a tanker longitudinal symmetry plane (2); and a distance between an inner side wall (18) and said heating coil bundle (20) closest straight tube (32) centerline ranges from 0.3 to 0.7; preferably from 0.4 to 0.45; times said tank (10) width.

4. The heating coil bundle (20) for the tank (10) heating of claim 3, wherein a tube pattern (22) vertical pitch to said straight tube (32) outer diameter ratio is at least 1.25; preferably at least 3.

5. The heating coil bundle (20) for the tank (10) heating of claim 4, further comprising at least one heating fluid transfer tube (36); characterized in that:

said heating fluid transfer tube (36) is hydraulically a single body with one fluid inlet and one fluid outlet;

said heating fluid transfer tube (36) is extended in parallel and spaced-apart relationship to said straight tubes (32); and

said heating fluid transfer tube (36) is fixed to said support (40) by using said plurality of fastening means (42).

6. The heating coil bundle (20) for the tank (10) heating of claim 5, further comprising at least one tube thermal expansion compensation device (38); characterized in that said heating fluid transfer tube (36) and said tube thermal expansion compensation device (38) are leak-proof serially joined at their open ends, providing a single body with one fluid inlet and one fluid outlet.

7. The heating coil bundle (20) for the tank (10) heating of claim 6, characterized in that said tube thermal expansion compensation device (38) is an expansion bend.

8. The heating coil bundle (20) for the tank (10) heating of any of claims from 4 to 6, characterized in that said fastening means (42) are U-shaped bolt and nut fasteners.

9. The heating coil bundle (20) for the tank (10) heating of any of claims from 4 to 6, characterized in that said support (40) is any single-part or any built multi-part structure capable of securely holding said heating coil bundle (20).

10. A tank (10) heating system comprising:

at least one said heating coil bundle (20) of any of claims 5 and 6; and

said heating coil bundle (20) of claim 4;

characterized in that:

said heating coil bundle (20) of any of claims 5 and 6 precedes said heating coil bundle (20) of claim 4, the last bundle in a row;

each said heating coil bundle (20) heating body possesses its heating fluid supply line and its heating fluid discharge line; wherein said heating fluid supply line and said heating fluid discharge line hydraulically connect a heating body inlet (31) and a heating body outlet (39) with the corresponding headers on a deck (16) level; and

said heating fluid transfer tubes (36) are conveniently utilized as sections of said supply lines and sections of said discharge lines.

AMENDED CLAIMS
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1. A tank (10) heating equipment, comprising a plurality of heating coil bundles (20), characterized by:

said plurality of heating coil bundles (20) is extended horizontally, close above a tank bottom (12), slightly asymmetrically positioned between an inner side wall (18) and an outer side wall (14);

said plurality of heating coil bundles (20) is exclusively extended in an exactly one row along a tank (10) length, in a longitudinally spaced apart manner; and

each one heating coil bundle of said plurality of heating coil bundles (20) comprises a plurality of straight tubes (32); a plurality of U-shaped tubes (34); a plurality of fastening means (42); and a plurality of supports (40) to form a compact and rigid structure, wherein said plurality of straight tubes (32) and said plurality of U-shaped tubes (34) are arranged in at least three parallel and vertically spaced apart heating coil tube levels (24), characterized in that, each one of said heating coil tube levels (24) comprises at least one said straight tube (32) of a unique distance between a straight tube (32) axis and said tank bottom (12).

2. The tank (10) heating equipment according to claim 1, wherein:

each one heating coil bundle of said plurality of heating coil bundles (20) comprises at least one heating body;

said plurality of straight tubes (32) and said plurality of U-shaped tubes (34) are leak-proof serially joined at their open ends providing said heating body with one fluid inlet (31) and one fluid outlet (39), where a joining sequence starts by joining said straight tube (32) and said U-shaped tube (34), then proceeds by a series of consecutive joining, on a U-shaped tube (34) open-end side, of tube pairs comprising said straight tube (32) and said U-shaped tube (34), respectively, and finally completes by joining yet another said straight tube (32);

said plurality of straight tubes (32) is fixed to said plurality of supports (40) by using said plurality of fastening means (42); and each one heating coil bundle of said plurality of heating coil bundles (20) is joined to said tank bottom (12) by using said plurality of supports (40).

3. The tank (10) heating equipment according to claim 2, wherein:
each one heating coil bundle of said plurality of heating coil bundles (20) is extended in a parallel and spaced apart relationship from a tanker longitudinal symmetry plane (2); and
each distance between said inner side wall (18) and each heating coil bundle (20) closest straight tube (32) centerline ranges from 0.3 to 0.7 times the width of said tank (10).

4. The tank (10) heating equipment according to claim 3, wherein a tube pattern (22) vertical pitch to a straight tube (32) outer diameter ratio is at least 1.25.

5. The tank (10) heating equipment according to claim 4, wherein at least one said heating coil bundle (20) further comprises at least one heating fluid transfer tube (36), characterized by:
said heating fluid transfer tube (36) is a single body with one fluid inlet (31) and one fluid outlet (39);
said heating fluid transfer tube (36) is extended in parallel and spaced apart relationship to said plurality of straight tubes (32);
said heating fluid transfer tube (36) is fixed to said plurality of supports (40) by using said plurality of fastening means (42); and
said heating fluid transfer tube (36) is conveniently utilized as a section of any one of heating fluid lines extended within the said tank (10).

6. The tank (10) heating equipment according to claim 5, wherein at least one said heating fluid transfer tube (36) further comprises a tube thermal expansion compensation device (38), said heating fluid transfer tube (36) and said tube thermal expansion compensation device (38) are leak-proof serially joined at their open ends, providing a single body with one fluid inlet (31) and one fluid outlet (39).

7. The tank (10) heating equipment according to any one of claims 4, 5, and 6, wherein said fastening means (42) is a U-shaped bolt and nut fastener and said support (40) is any single-part or any built multi-part structure capable of securely holding any one heating coil bundle of said plurality of heating coil bundles (20).

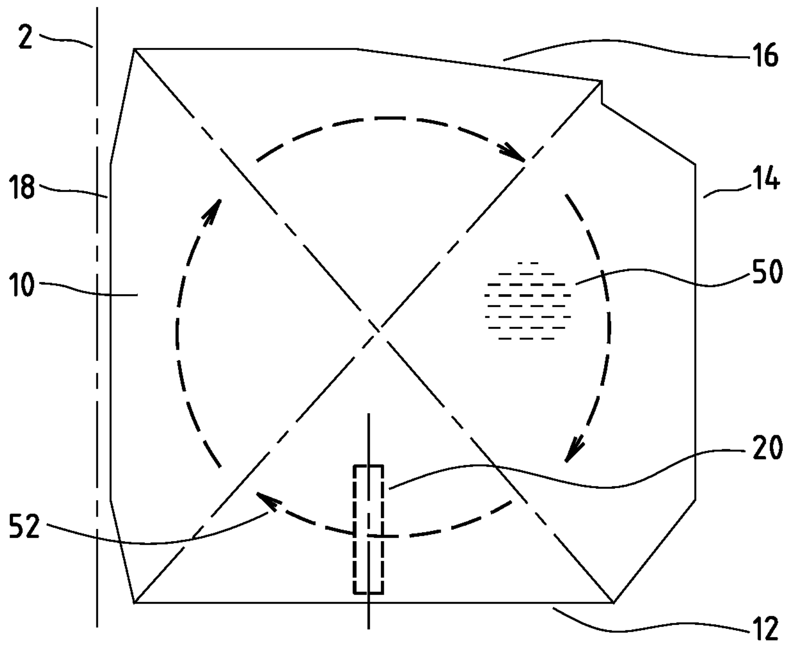

Fig. 1

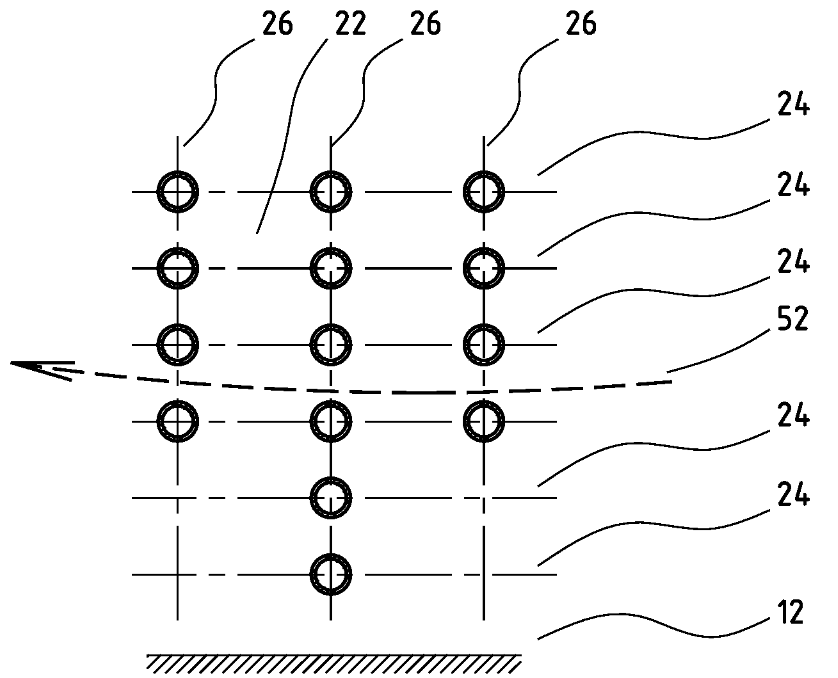

Fig. 2

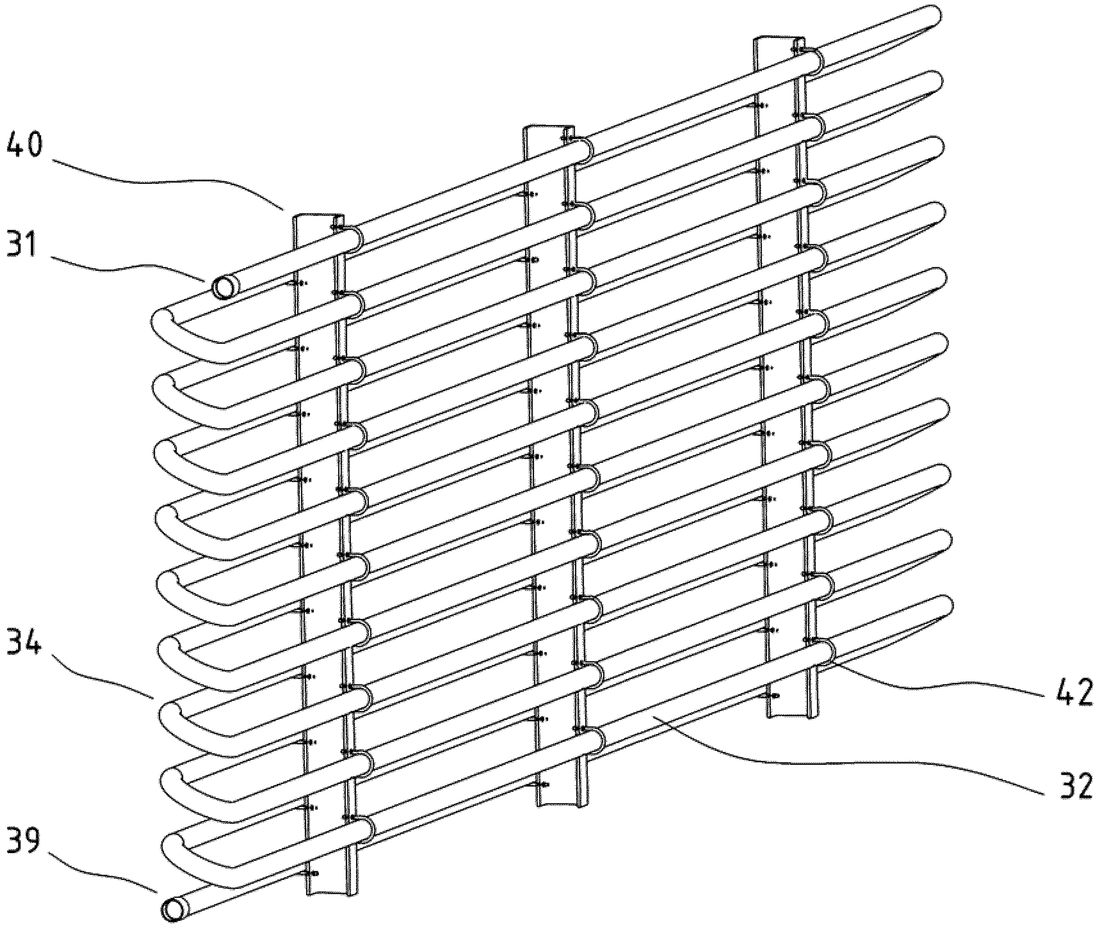

Fig. 3

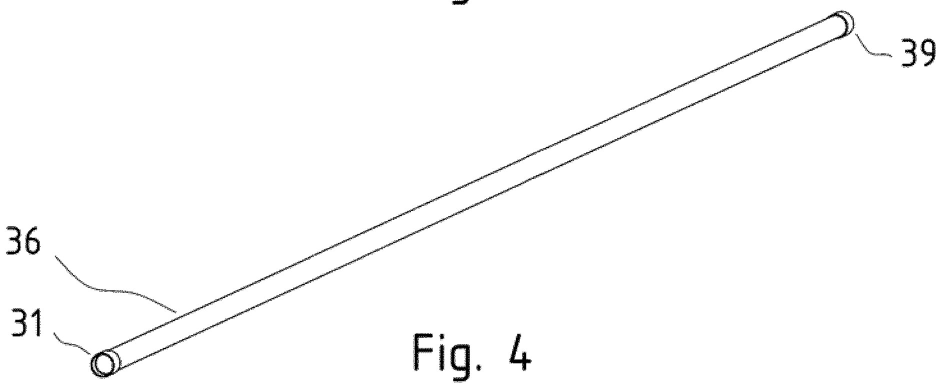

Fig. 4

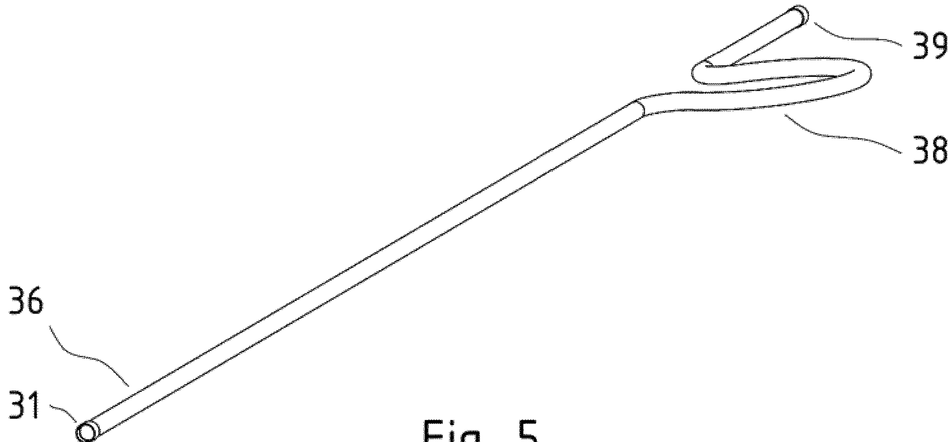

Fig. 5

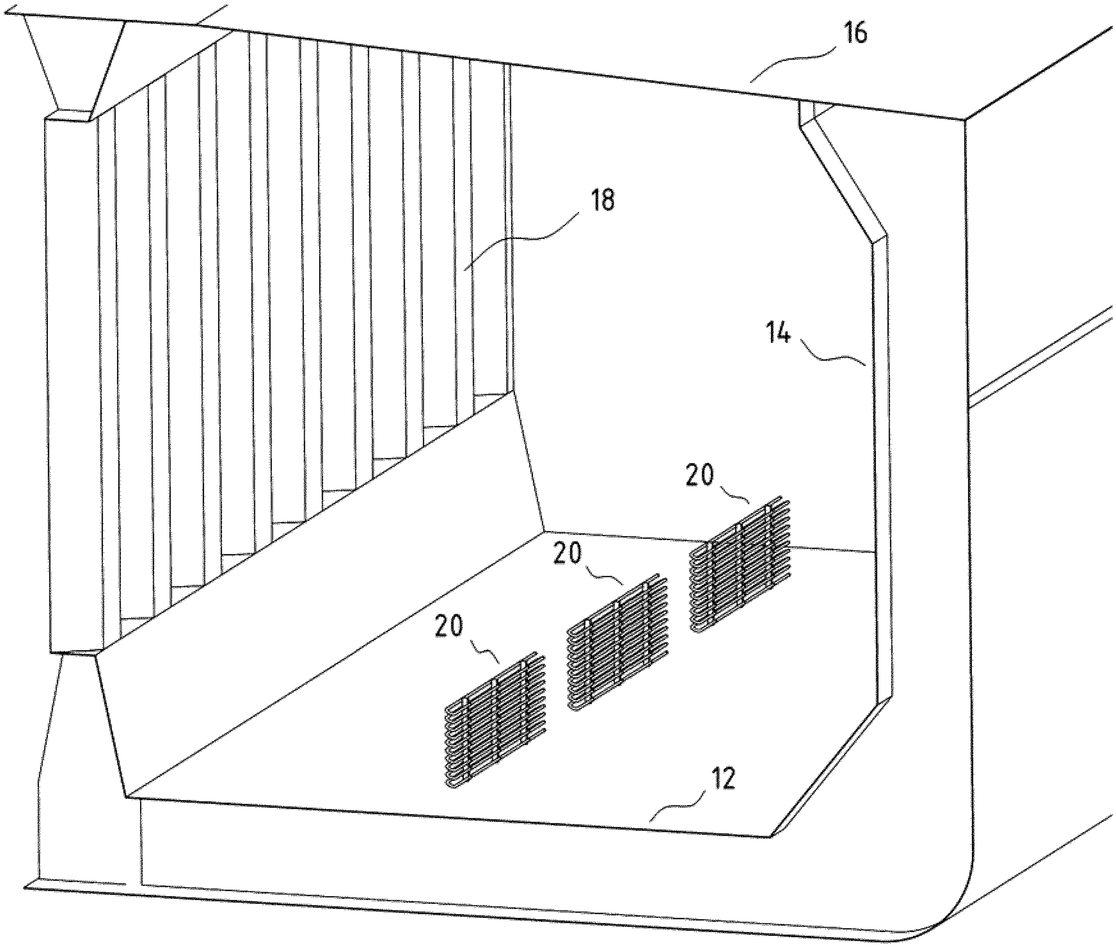

Fig. 6

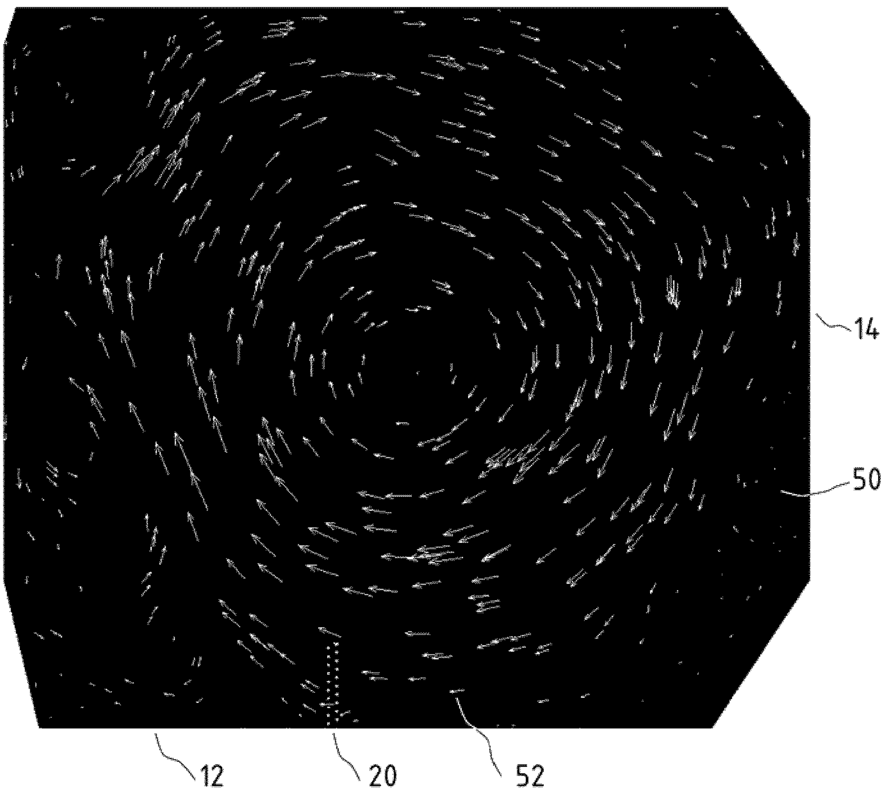

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/066423

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63J2/14 F22D1/08 F28D1/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63J B63B F22D F28D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 3 048878 U (HIDEKI MATSUSHIMA EHIME) 29 May 1998 (1998-05-29) figures 1-4	1-10
X	CN 101 362 509 A (WENCHONG SHIPYARD CO LTD [CN]) 11 February 2009 (2009-02-11) figures 1,2	1-5,10
X	JP H05 69893 A (SHINKURUSHIMA DOCK KK) 23 March 1993 (1993-03-23) abstract; figures 1-3	1-10
X	JP 2007 238054 A (SUMITOMO HEAVY IND MARINE & ENG CO LTD) 20 September 2007 (2007-09-20) para. [0014], [0015], online translation; abstract; figures 1-4	1-5
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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Date of the actual completion of the international search	Date of mailing of the international search report
4 September 2018	13/09/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Mauriès, Laurent

1

International application No
PCT/EP2018/066423

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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